



Electroplate Alternatives to Hard Chrome: Nanocrystalline Metals and Alloys

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About Integran

Background

- Pioneer in microstructurally engineered metals
- Nanostructure alloys - Enhanced durability, strength, wear resistant
- Coatings, CFRP/composite tools/parts, and functional hybrid polymer-nanometal parts for aerospace and automotive

Intellectual Property

- Over 100 patents on production of metallurgical nanostructures
- First nanomaterial technology patent ever issued

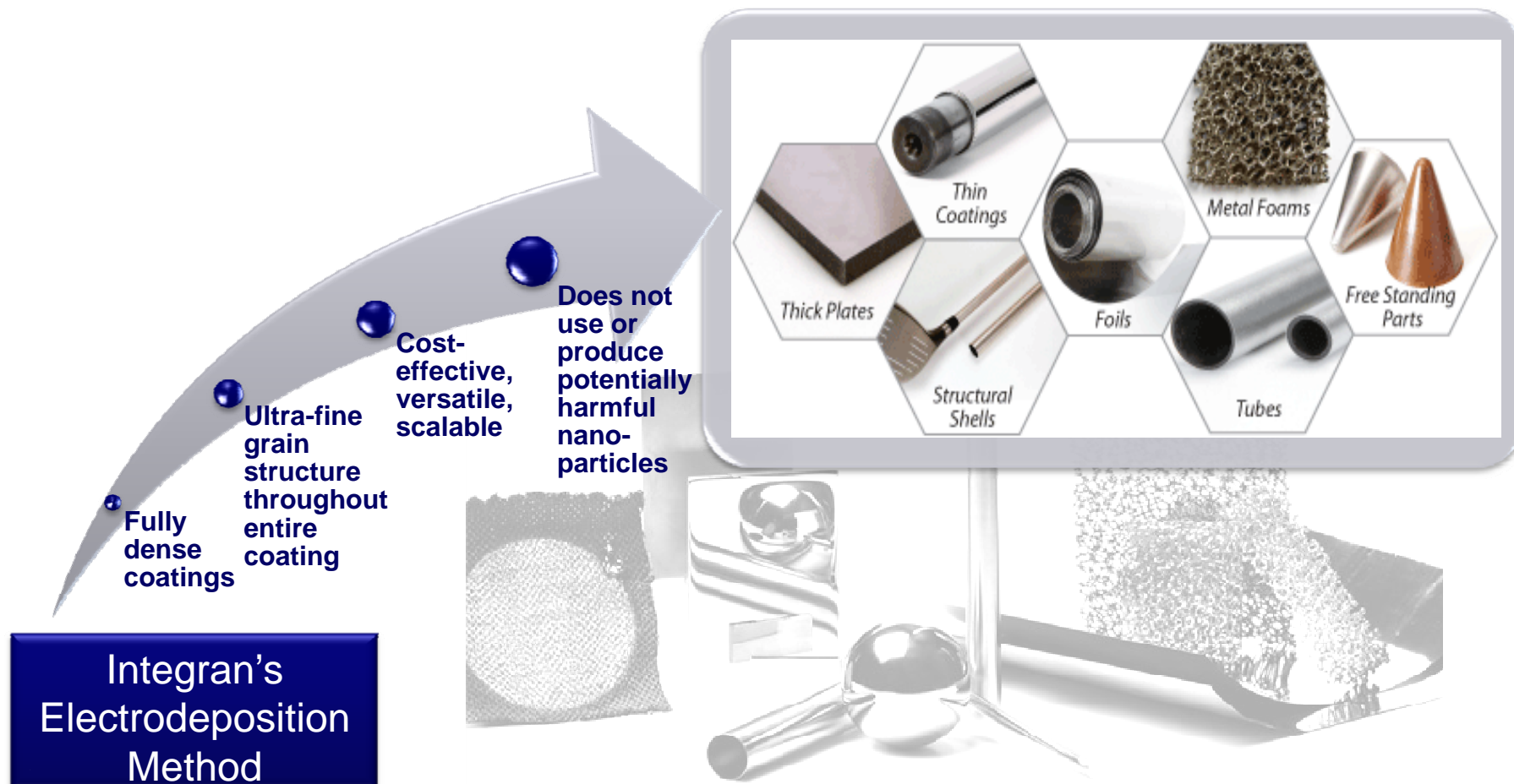
Facilities

- Applications company - Facilities and partnerships in Toronto, Canada, Pittsburgh, PA USA, and Carlsbad, CA and Tijuana, Mexico.



Production Process

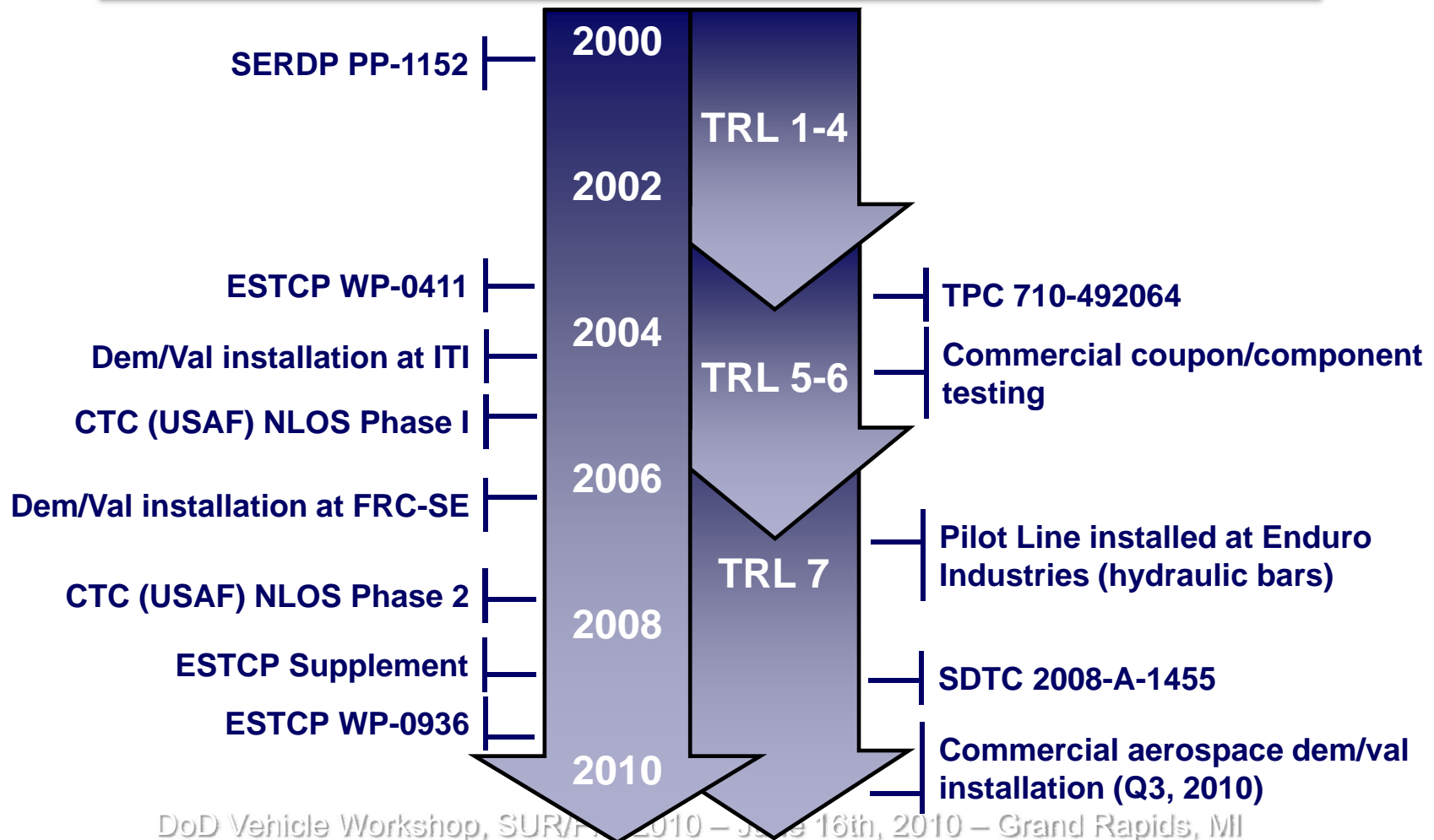
Patented pulsed current electrodeposition process provides a cost-effective, versatile synthesis method to produce high quality nanocrystalline metals and alloys



Hard Chrome Alternative

Nanovate™ CR nanocrystalline cobalt alloy

- Developed and demonstrated at the lab scale
- Scaled up to industrial production & moved to DoD depot



Process (at TRL 7)

Nanovate™ CR provides significant process improvements over chrome

- Environmentally compliant
- High deposition rate
- High current efficiency
- Drop-in technology
- Excellent bath stability
- JAX, Enduro, SDTC–DemVal Aerospace

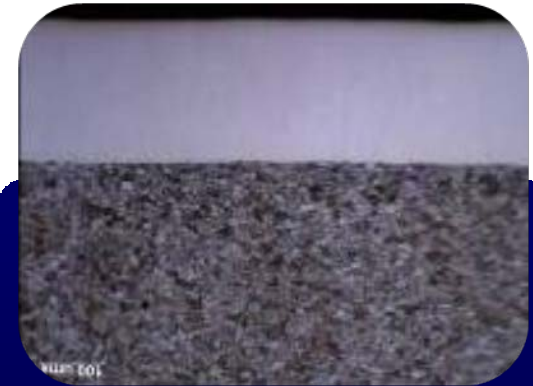


	Nanovate™ CR	Hard Chrome
Deposition Method	Electrodeposition	Electrodeposition
Applicable Geometries	LOS and NLOS	LOS and NLOS
Efficiency	85-95%	15-35%
Deposition Rate	50 – 200 μm per hour	12 – 25 μm per hour
Emission Analysis	Below OSHA limits	Cr^{+6}

Properties

Nanovate™ CR reduces friction, enhances wear & corrosion resistance

	Nanovate™ CR	Hard Chrome
Appearance	Free of pits, pores & cracks	Microcracked
Hardness (VHN)	530 – 680	Min. 600
Wear volume loss (10⁻⁶ mm³/Nm)	6 – 7	9 – 11
Coefficient of Friction	0.4 - 0.5	0.7
Corrosion Resistance (1000 h)	Protection Rating 8	Protection Rating 2
Hydrogen Embrittlement	Pass with bake	Pass with bake

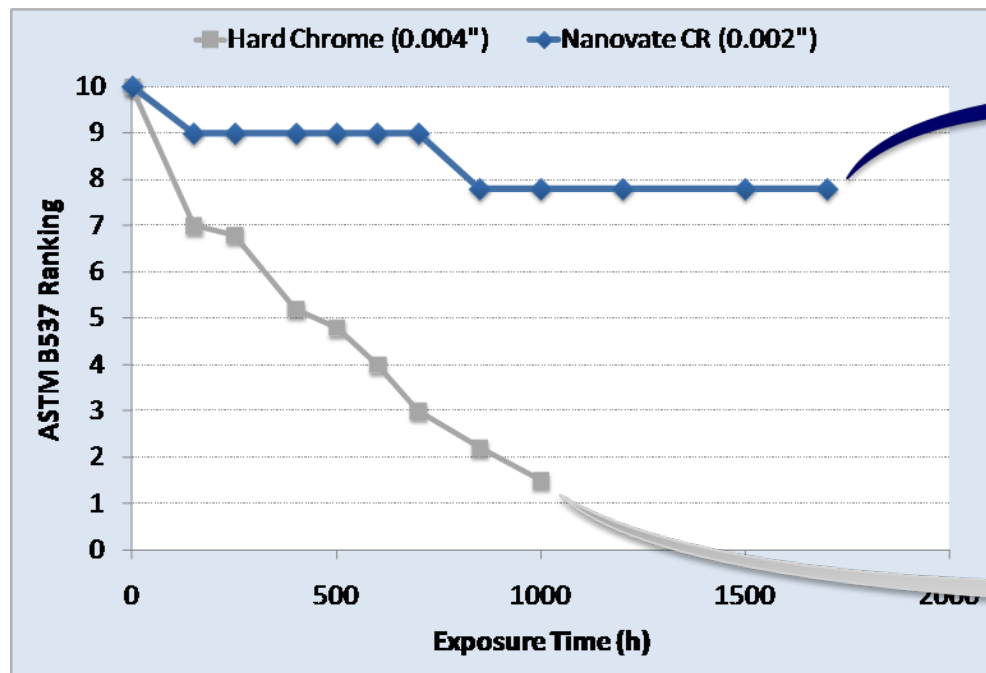


Nanovate™ CR
Pit, pore and crack-free

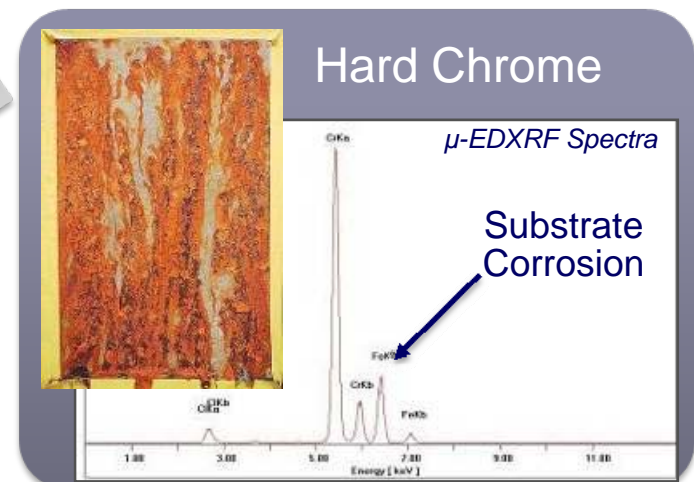
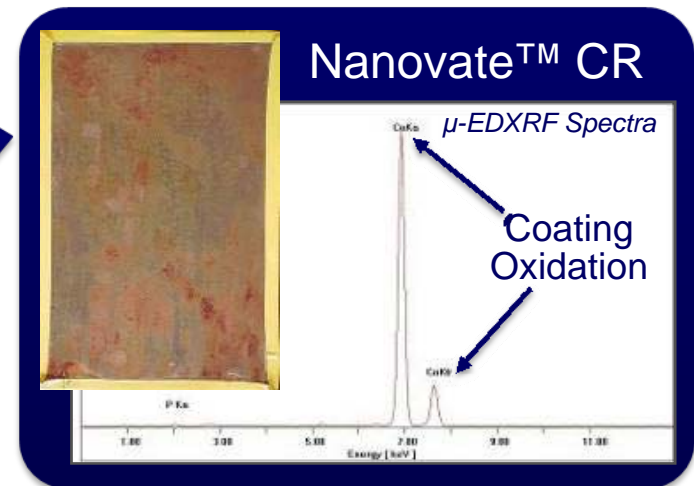


Hard Chrome
Microcracked

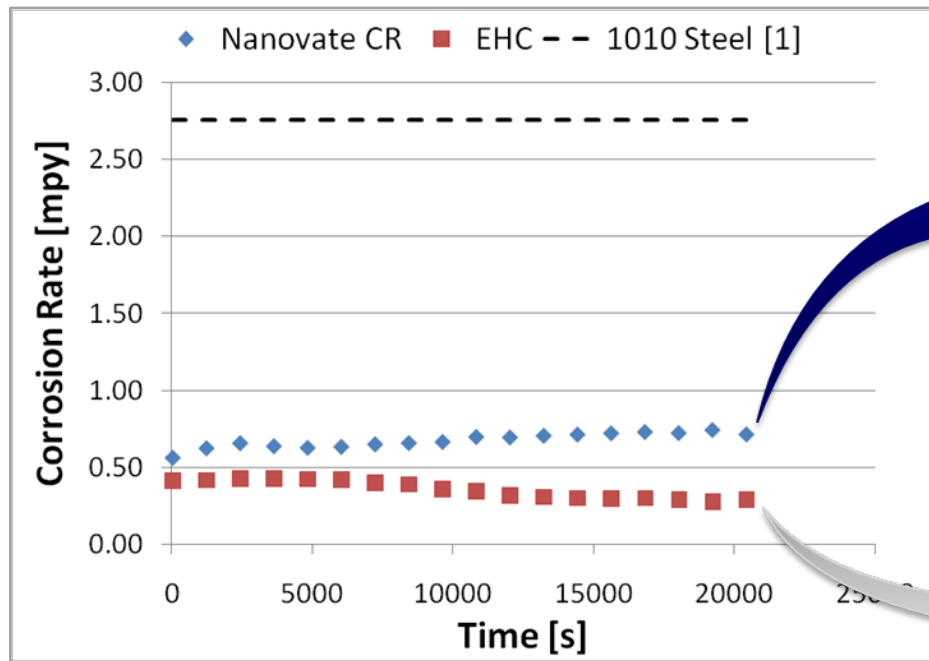
Nanovate™ CR provides enhanced corrosion protection



**ASTM B537 Ranking following 1000h
ASTM B117 Salt Spray**



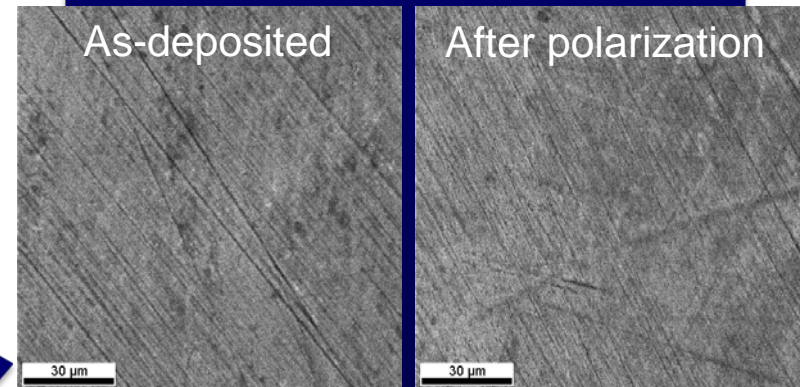
Nanovate™ CR provides corrosion protection in aqueous environments



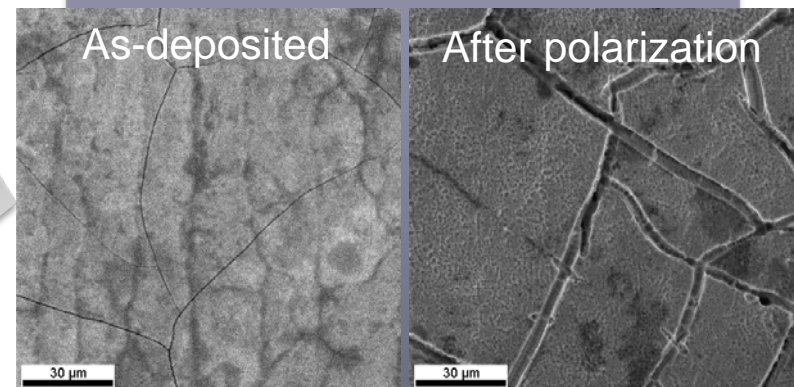
Linear Polarization
In 3.56wt% NaCl, aerated

[1] Luis Caceres, Tomas Vargas, Leandro Herrera, Corros. Sci. 47 (2007) 3168–3184.

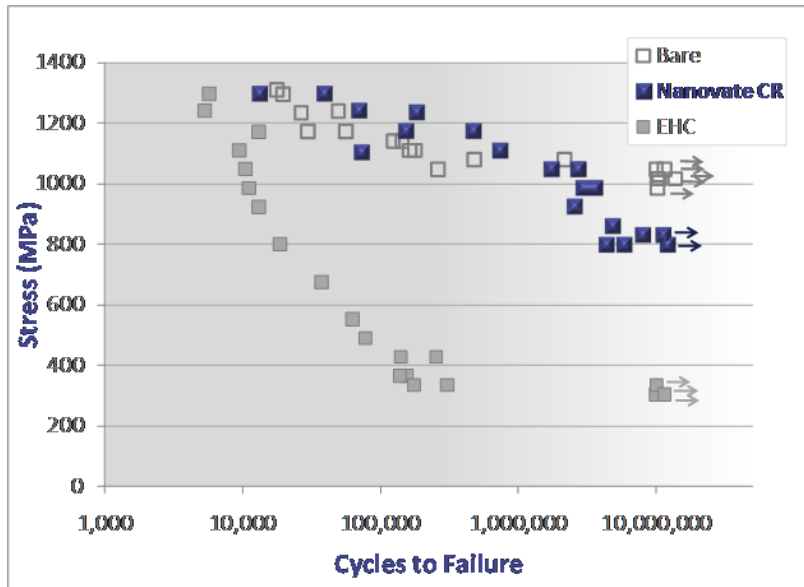
Nanovate™ CR



Hard Chrome



Nanovate™ CR enhances fatigue life

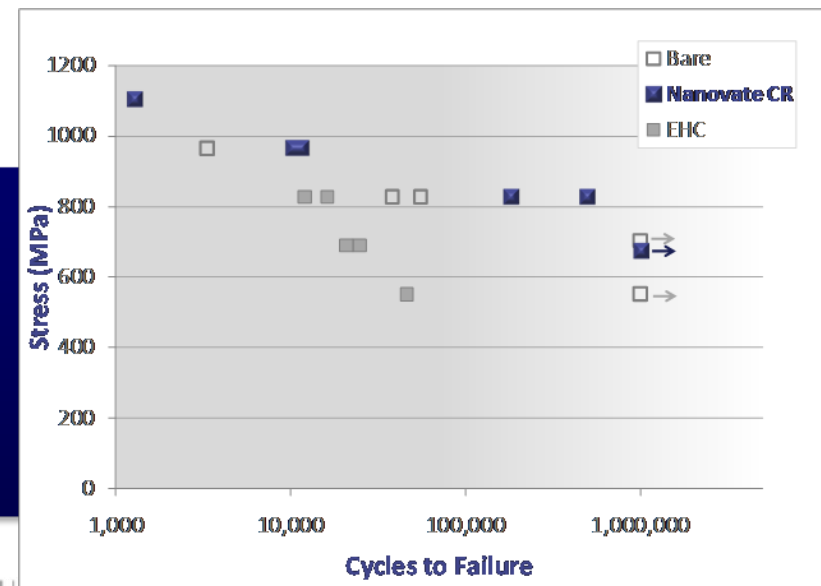


Rotating Beam Fatigue

- 4340 substrate (UTS: 1790-1930 MPa)
- Significant credit vs. chrome
- Comparable to bare

Axial Fatigue

- 4340 substrate (UTS: 1240-1380 MPa)
- Preliminary data
- Credit vs bare & chrome



- **FRC-SE (NAVAIR JAX)
Dem/Val Process Line**

- 250 gallon Plating Tank (2.5'x4'x4')
- 370 gallon Activation Tank (3'x3'x6')
- Pulse Power supply (1500A Peak Current)
- Remote Controller (Dynatronix)



Dem/Val Plating Tank



Power Supply



Remote Controller



Acid/Fluoride Activation tank

- **Sample Aerospace Applications**

- OEM and rebuild/repair
- Gas turbine engines
- Actuators
- Landing gear
- Propeller hubs
- Valves
- Pistons
- Shocks



Success Story: Enduro Industries

- Commercial scale deployment of Nanovate™ CR
- Produce Nanovate™ CR-coated hydraulic actuators for fluid power



**Nanovate CR production
plating line at Enduro
Industries (Hannibal, MO)**

T-45 Arresting Hook Pivot Assembly



A/S32A-32 Aircraft Towing Tractor "Spotting Dolly" Spread Cylinder Hydraulic Rod

- Marine Corps MK48 LVS (Logistic Vehicle System) Hydraulic Cylinders
 - Reduce corrosion maintenance requirements and repair costs of vehicles
 - Test plan
 - Bench testing on carburized steel panels (in progress)
 - Accelerated corrosion testing (GM9540P)
 - Field test on MK48 vehicles



Summary



Nanovate™ CR Hard Chrome Alternative

- Environmentally compliant EHC alternative
- Process compatible with existing plating infrastructure
- Reduced energy consumption, increased throughput
- Enhanced corrosion and wear
- Non-embrittling
- Improved fatigue performance vs. EHC

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